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Design of Shadow Controlled Rescue Robot

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***Abstract*—** The main objective of the proposed system is to rescue the infants who accidentally fall and get trapped into the bore well due to improper maintenance at the digging spot. The proposed system is a robot which can crawl into the bore well and lift the infant from the well with the help of two 3DOF robotic arm which is controlled by gesture of the human arm which is termed to be called as "shadow control technology" in this system and the robot get a human touch in its control by this technology and reduces operation time. This also helps to rescue the infant from any orientation they are present. The robot can also be used in applications like scavenger cleaning and pipe inspection with some minor changes in the end effectors which are discussed later in the system.

Keywords—borewell,rescue,shadow controlled arm,pipe inspection,scavenger cleaning

I. INTRODUCTION

Generally in India many bore wells are dug for irrigation purpose and for other water necessity. These bore wells sometimes get dried up due to over usage or lack of water in the ground water level and even sometimes the digging mission fails due to the absence of water even after digging some 1000feet. Such unsuccessful or unused bore well are not closed and kept as it is, which sometimes becomes a threat to infants. On an average, there were 27 bore wells per square kilometer of Punjab, 22 in Uttar Pradesh, and 14 in Haryana. Interestingly, even small and marginal farmers accounted for over two-thirds of the households that own bore wells. Initially, open wells were dug and centrifugal pumps were used to extract groundwater but nowadays farmers started drilling bore wells from the early 1990s and shallow open wells gradually dried up due to falling groundwater levels across the world. Over the last 15 years, the number of bore wells grew rapidly in these villages in India. The infants' falls into the bore well accidentally in many cases and lose their lives, due to lack of technology or equipment to rescue them. Thus the proposed system aims at creating such novel equipment.

The proposed robot can also be used in scavenging. In India scavenging is mainly done by humans due to lack of such an equipment and hence this system can replace manual scavenging since the robot's manipulators behave like a human arm by gesture control and can even be controlled over a very long distance.

II. LITERATURE VIEW

The solutions to rescue robots

Available solutions

Till now there is no proper solution to rescue the infant from the borewell safely. The rescuers usually dig a hole parallel to the victim's borewell and create a horizontal path to reach the infant. It takes more time, energy and resources to rescue the infant.

Fig.1 Available solution

And in some cases rescuers use some hook like structure or gripper setup to lift the infant. But these arrangements hurt the infant very badly.

Possible alternative solutions

Robots came into existence very recently and it replaces humans in many hazardous life-saving operations. Thus developing a rescue robot which can crawl into the borewell and with the help of shadow controlled arm technology, the infant could be rescued safely without getting hurt.

Pipe inspection and cleaning:

The pipe inspection is the very useful method of inspecting and it's of high demanded equipment. Because after laying of pipes is very difficult to inspect the pipes for any damage, dust and cleaning. The existing solution is with the help of a wired camera and a receiver at the other end of it and thus it decodes the signal and processes it.

Difficulties in existing solution (pipe inspection):

The wire transmission of signal for very long distance underneath earth in vertical direction is impossible to build, and needs highly costly equipment's for the setup.

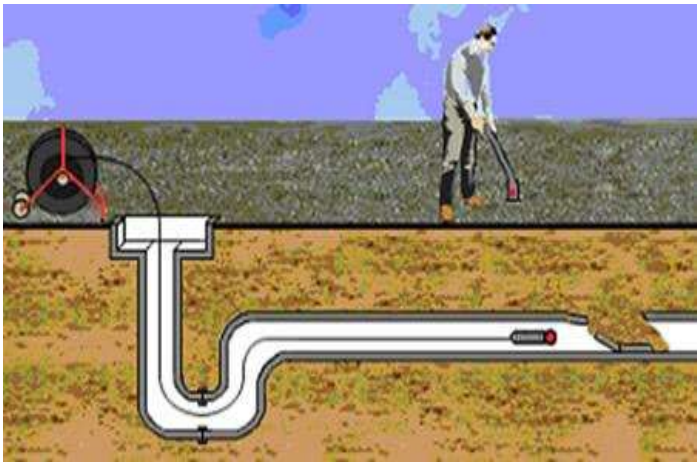

Fig.2 Existing solution for pipe inspection

Manual scavenging:

Manual scavenging is a process of removing blocks/cleaning the drainage with the help of a human. In this process the human is sent into the drainage without any protection or suit and the human accomplishes the task of cleaning the dirt present in the drainage manually. This involves the human life and risk due to many toxic gases that are present inside the drainage. These toxic gases when breathed would act as great hazardous to human lives and can also act as a slow poison. The humans indulging in such scavenging activities are prone to death easily. So to overcome such process scavenging can be automated with the help of a robot and the process of automating the scavenging process using a robot is one of the objectives of the paper.

We have come with a solution which gets rid of all these problems with a help of a robot which is driven by DC motors, with a shadow controlled arm, here the shadow controlled arm gives a human touch to the robot, so controlling can be done by even a normal people, as well as a HD camera fitted is a great help to monitor things. The robot we do is sturdy one, which can perform in all weather conditions. For the scavenger cleaning there is a market available setup which is just to be needed to fix at the bottom.

Fig.3 Media report

III. DESIGN CONCEPT

OBJECTIVES

- To design and fabricate the Shadow Controlled Rescue Robot
- To inspect the pipe line / bore-well for defects
- To scavenger clean the pipe lines
- To test the successful working

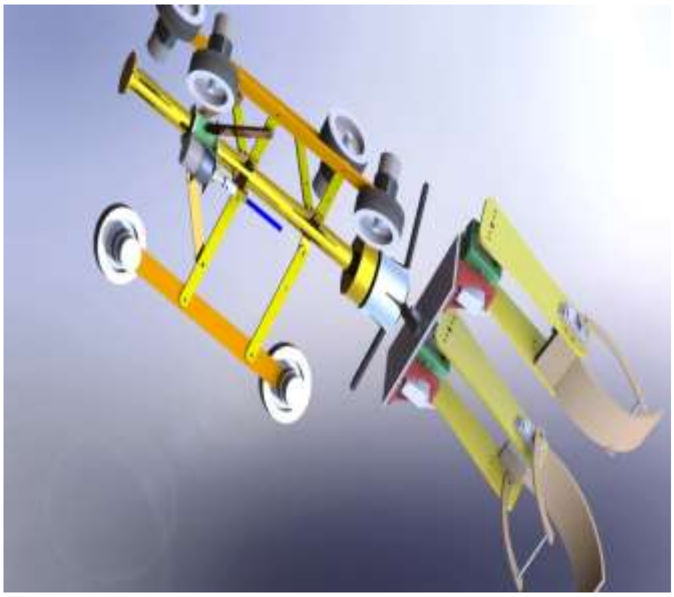

Fig.4 CAD design

The proposed robot has to maneuver through the bore well and pipes. So the main frame of the body is designed in such a way that it has three parallelogram based expanding and contracting arms spaced at 120 degrees each and containing two wheels at either ends of a single link out of which one of them is actuated with the help of a DC motor of obtained torque in the calculations made. The robot should be capable of pick objects and hence two robotic arms similar to a human body is placed with only 3DOF to avoid complexion. These robotic arms are controlled with the shadow control technology to make the control easier and use friendly for the operator. This entire system is supported by ropes for lifting it from the bore well without any issues.

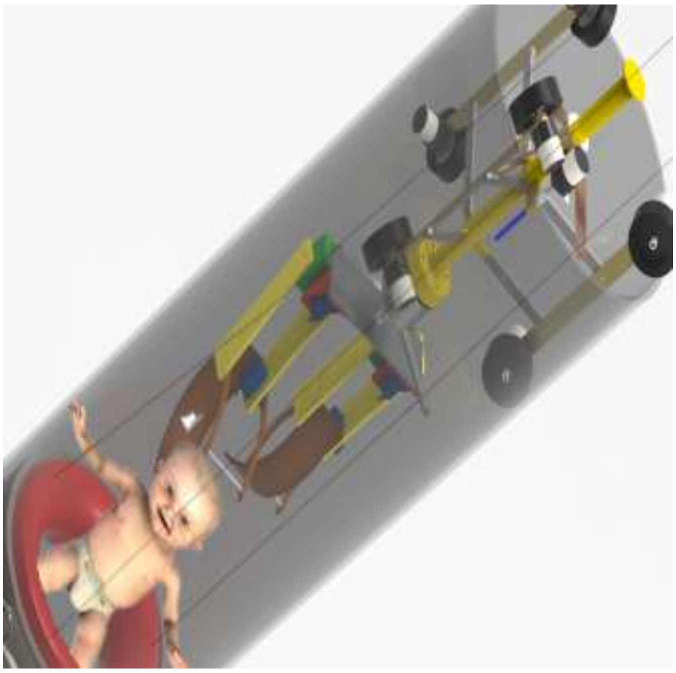

Fig.5 CAD simulation

The entire system is hold from the top using ropes for extra support and reliability as shown in figure 5.

IV. METHODOLOGY

Main mover Mechanism

The main mover of the robot is fully made up of aluminum. Hence the body is light weight as well as rigid for the required stress acting. The stem of the main mover is made of aluminum pipe of 1inch outer diameter with a thickness of 5mm. A slider is kept at the outer of the pipe. This slider will slide freely in the gap of the outer surface, with a clearance of 0.5mm. The main mover has many links which behave like a screw jack, i.e. It can increase or decrease in height which is necessary to us. The link has two ends in which one end is directly connected to the aluminum by a pin joint, and the other end is connected to the slider. This slider slides to and fro, for the increase and decrease in the radius of the links. The slider is attached with a 12V DC motor of 100rpm, which can rotate in both the directions; this motor is connected with a bolt of size 12mm.

Straight to the bolt there is a nut which is welded to the pipe i.e. stationary. The bolt powered by the motor is let into the nut that is stationary and welded, the motor which is connected to the slider, now when the motor rotates, the bolt will rotate resulting in moving inwards or outwards the nut, this results is the upward and downward motion of the slider, which in turn results in the increase or decrease of the radius of the links. There are totally three sets of link with the same mechanism. The links are attached with motors for locomotion. The rotating mechanism consists of a 12V DC motor of 10 rpm. The rotating mechanism consists of a motor mounting. This motor mounting is rigidly fixed to the pipe and the motor is attached with a plate in which the arm is being mounted.

Fig.6 Complete main mover

Shadow Controlled robot arm

The robot arm is the main advantage of this robot. This arm is controlled by the human gesture i.e. the arm is controlled by the human motion, without the use of any switch. The motion of the human is replicated by the robot arm. The robot arm is fixed to the bottom of the rotating part of the main mover, the rotating helps in getting an extra degree of freedom for the robot arms. The robot arm is powered by the help of servo motors. The servo motors are used so that the degree of rotation can be controlled. The servo motors are fixed to the rotating part by servo mountings.

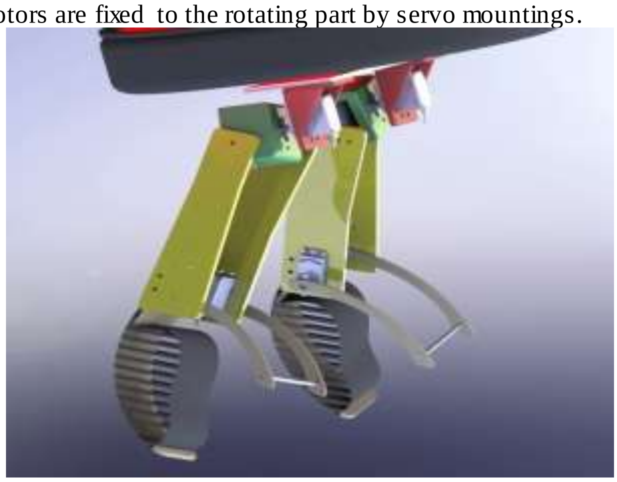

Fig.7 Robotic arm with gripper

These mountings are specially designed and fabricated by 3D printing technology. The 3d printed

mountings make the servo motors sturdier. The first servo is mounted with a bracket with the plate of the rotating part of the main mover; this servo acts as the elbow of the human to the robot. The next servo is attached with the first servo is directly by attaching the mounting to the shaft of the servo; this servo acts as the wrist of that of human to the robot. The final servo is for the gripper, the gripper acts as fingers in humans. This gripper is the highlighted part of any robot.

Shadow suit:

The shadow suit consist of a glove which is easily wearable to the humans, the glove is attached with the flex sensor, which give values to our movement and the servo motor is controlled. There is another setup made of sheet metal which is the motion control of the potentiometer. This is very easily wearable and easily controllable.

Fig.8 Shadow suit

The suit is specially designed for the easily wearable and use by any individual even without any prior knowledge of electronics. The suit is even more easily controlled than that of the normal switches as it is simply the normal hand movements of the human which is transferred to the robot.

Control box:

The control box consist of microcontroller, which is the brain of the system, it get values compare the conditions and do the right things needed to be done. It also contains switches for the control of the locomotion and a kill switch for any dangerous hazards if happened.

In this control box, the batteries are also kept within which makes it compact and simpler to be transported without any damages in the circuit board. There are a few switches for the power ON/OFF of the servo motors, LED, microcontroller., so if there is any damage or any short circuit if happens it is easy to save the board from damaging.

Fig.9 Control box

Balloon gripper:

Thus in case of worst case scenario in lifting the infant with arm, the arm is used to position the infant to the Centre of bore well diameter and then the balloon gripper will be projected over the infant and it is inflated. Thus it holds the infant grip. The outer shell is made of hard rubber material which will prevent the balloon to get inflated outwards the child (towards the wall).

Fig.10 Balloon gripper

Overview:

The main mover is the body of the robot which helps in the locomotion and grippig of the robotat a certain place. It can make the robot move in various sizes of tubes which is the main advantage. The shadow controlled robot arm is the added advantage which gives a human touch to the robot. The shadow suit helps in easy and flow control to the robot. The robot arm helps in picking of the objects and gripping it. the gripped body can be pulld up with the help of a rope in the

top. This is the most easy and effective way to do a rescue operation.

V. Design Calculations

The infant weight is assumed to be 30 kg
Gripper jaws are parallel to each other
Assume the infant is being grassped at 12 inches from COG
The jaws gripping surface is 4 inches wide
Assume the infant hand width to be 3 inches at the point being grasped
Let the lifting force (vertical) be 2.5G and 1.5G to move the infant horizontally
Let the coefficient friction between the gripper and infant is 0.85
let Saftey factor = 1.5

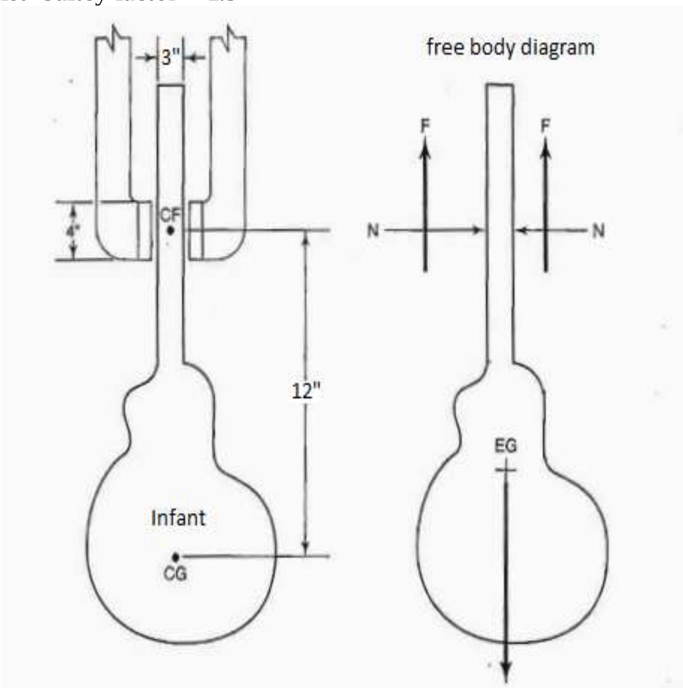

Fig.11 Gripper force

The infant excerts a stationary force of 30 kg with 1.5G while moving
Therefore 30*1.5 =45 kg
45 / 4 = 11.25 kg of force is exerted by each 2 sides of gripper
Friction force = coefficient of friction * normal force

$$N = \frac{F}{\mu} \quad ; \qquad N = 11.25 / 0.85$$

$$N = 13.235 \text{ kg}$$

Since Saftey Factor is 1.5
N = 1.5*13.235 = 19.852 kg

Thus force of 20kg (approx.) is required for each gripper to hold the infant.

5 DEGREE OF FREEDOM DESIGN

Assume efficiency of servo mtor to be 90%

Let Force req. for positioning the infant to the centre is 60 N

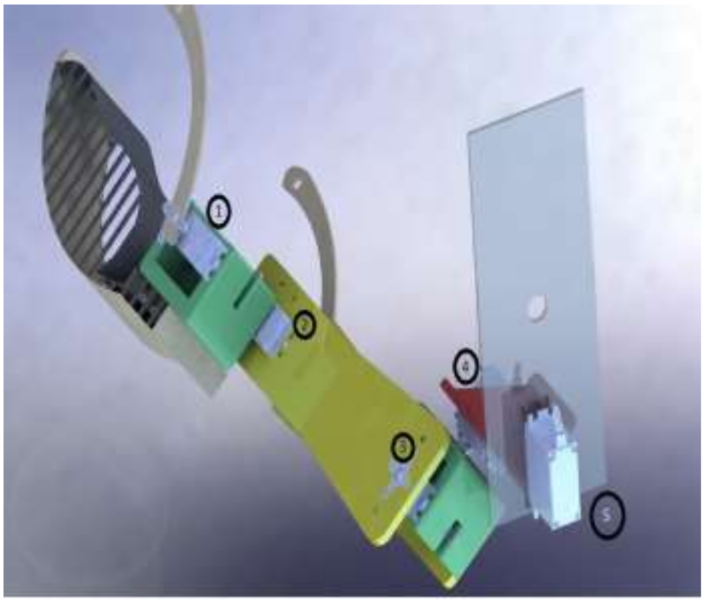

Fig.12 5 DOF arm design

Servo motor Torque calculation

Table .1 servo torque calculation

	Mass(kg)	Length (cm)	Centre of mass(cm)
Link 1	0.150	10	5
Link 2	0.100	10	5
Link 3	0.210	21	10.5
Link 4	0.100	2	1
Joints	0.210	nil	nil

Table. 2 servo acceleration

	Acceleration (deg s^-2)
Joint 1	10
Joint 2	10
Joint 3	0.8
Joint 4	0.8
Joint 5	0.8

Step1: Consider 2 DOF

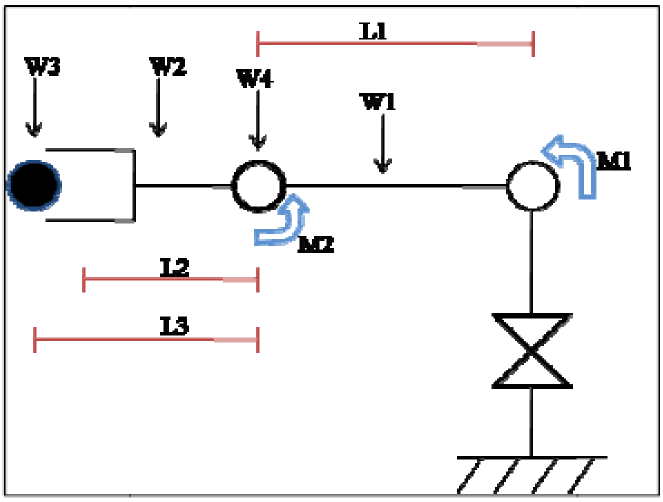

Fig.13 Free body diagram

Formulae :

(1) Torque at M1 = [W1*L1/2 + W4*L1 + W2(L1+L2/2) +W3(L1+L2/2) + W1(L1/2)^2 +W4(L1)^2 + L2(L1+(L2/2)^2) + W3(L1+L2)^2 * (ACCELERATION OF JOINT 1) * 3.141] / 180 * EFFICIENCY OF MOTOR

(2) **Torque at M2 = [** W2*L2/2 + W3*L2 + W2(L2)^2 + W3(L2)^2 * (ACCELERATION OF JOINT 2) * 3.141] / 180 * EFFICIENCY OF MOTOR

Step 2:

Thus using this above equation torque calculated for each motor is

Torque at M1 = 19.231 kg-cm
Torque at M2 = 20.004 kg-cm
Torque at M3 = 38.957 kg-cm
Torque at M4 = 39.925 kg-cm
Torque at M5 = 40.056 kg-cm

VI. DESIGN ANALYSIS

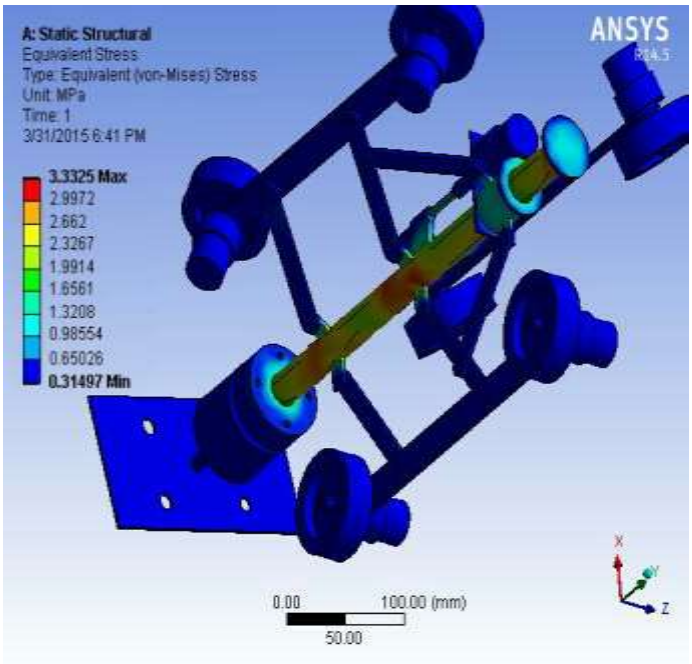

Fig.14 Stress analysis (von-misses)

FOS = yield strength / ultimate strength
FOS > 2 (therefore **DESIGN IS SAFE**)
Material choosen = Aluminum 1060 h-12 alloy
Density = 2705 kg/m3
Yeild strength = 65 mpa
Elastic modulus = 69000 n/mm2
Poisson's ratio = 0.3
Max of 3 mm is the displacement for the load value of 1000 N

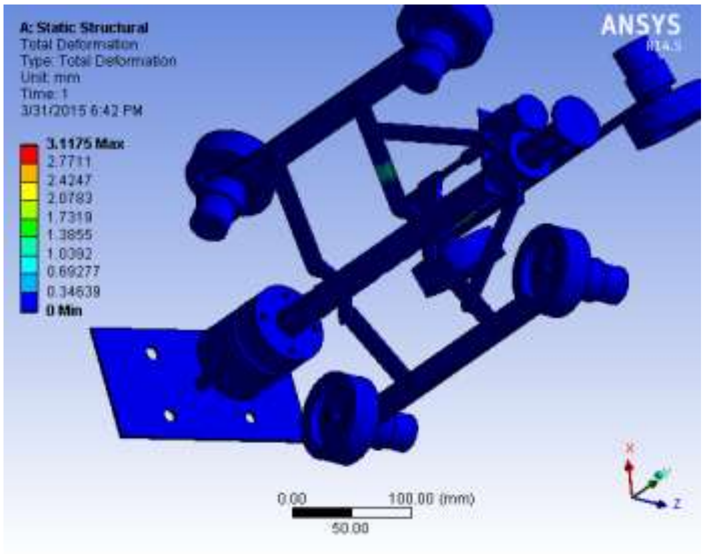

Fig.15 Strain (total displacement) analysis

CONCLUSION

It is concluded that the rescue robot can help in rescuing the victims at its fastest way. And it can also be used in disaster rescue operations like earthquake etc. But the main application of this robot is to rescue the infant who accidentally trapped into the borewell. Since the shadow controlled arm is an added advantage to this robot, it has wide applications.

As this robot is also capable for other applications such as scavenger cleaning and pipe inspection this will have a huge demand in the future as human scavenging is strictly banned all over the world.

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Animation video of our rescue robot for clear understanding.